<u>www.ijser.in</u> ISSN (Online): 2347-3878, Impact Factor (2015): 3.791

FPGA Implementation of an Adaptive Edge Enhancement Algorithm for Video Applications

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Abstract: In this paper, an adaptive edge enhancement technique is proposed for two-dimensional (2-D) image scaling application. The anticipated image scaling algorithm consists of an edge detector, bilinear interpolation and sobel filter. The bilinear interpolation defines the intensity of the scaled pixel with the weighted average of the four nearest neighboring pixels, interpolated images become smooth and loss of edge information. The adaptive edge enhancement technique is used to protect the edge features effectively, to achieve better image quality and to avoid the loss edge information. The filter attempts to reduce the noise, in blurred and distorted edges which is produced by bilinear interpolation. An algebraic manipulation and hardware sharing technique are used to reduce computing resource of the bilinear interpolation. The analysis shows that edges are well preserved and interpolation artifacts (blurring) are reduced. Compared with the previous low-complexity techniques, our method performs better in terms of both quantitative evaluation and visual quality.

Keywords: Bilinear interpolation, Edge detection, Image zooming, Sobel filter

1. Introduction

Image scaling is the process of resizing an image by pixel interpolation, used in computer graphics, medical image processing (such as endoscopy), and digital image devices (such as mobile phones, digital cameras and touch panel computers). An obvious application of image scaling is to scale up images to fit high- definition television (HDTV) and scale down the high-quality pictures or video frames to fit the minimize liquid crystal display panel of the tablet PC.

The image scaling algorithms can be split into two types: polynomial-based and non-polynomial-base methods.

The polynomial- based methods are nearest neighbor bilinear interpolation, bicubic interpolation, and interpolation. One of the simplest methods is nearest neighbor interpolation, where each interpolated output pixel is assigned to the value of nearest sample point in the input image. The resulting images of this method are full of blocking and aliasing artifacts. So it is unable to use in high quality imaging applications. The advantage this method are easy to implement and computationally fast, but it does not give good quality of images. Another method is bicubic interpolation; it is based on extended cubic model to scaled images in 2-D regular grid. This algorithm has benefit to produce of high quality images. However, it is computationally expensive due to the complexity in its computation and memory requirements.

Bilinear interpolation method which uses linear interpolation can be performed in both horizontal and vertical directions. This method is most widely-used because it reduces the blocking and aliasing effects.

Recently, many popular non-polynomial based methods have been proposed such as bilateral filter [1], blending kernals [2], adaptive 2-D autoregressive model [11], HVSdirected neural network [12] and orientation adaptive interpolation [13]. These algorithms improve image quality and also reduce aliasing and blurring effects but it has memory requirement, high complexity so it is not easy to be realized in VLSI technique. Low complexity methods are necessary for VLSI implementation.

One of the resampling methods is winscale algorithm [14]; it uses area coverage of original pixels for measuring new pixels of a scaled image. However, this method requires more time to calculate area coverage. Hardware cost is low but resulting images are undesirable block and blurring effects. A fuzzy image interpolation [10] combined a fuzzy inference system and an image interpolation technique. An adaptive low-cost and high quality image scalar [4], uses a filter combining and hardware sharing technique are used to reduce chip area and memory requirement.

A clamp and sharpening spatial filter are used to decrease the blurring effects produced by the bilinear interpolation. The proposed algorithm consists of a sobel filter, edge detector, and bilinear interpolation. The sobel filter and edge detector are used to enhance the edges of the source images and decrease the blurring effects caused by the bilinear interpolation. The experimental results show that this design improves image quality. The proposed scaling algorithm is designed by Verilog HDL.

2. Proposed Scaling Algorithm

Figure 1 shows the block diagram of an adaptive edge enhanced scalar architecture. It consists of a sobel filter, edge detector, and bilinear interpolation. Initially, a color image is converted into gray level image using MATLAB. Now gray level image converted into binary image. This binary image is resized and written into a text file. Store the binary image (Text file) into the RAM. Read the Text File from memory Bank. Memory bank provides the input to the sobel filter and edge detector. Further simulation is done by Modelsim. www.ijser.in

ISSN (Online): 2347-3878, Impact Factor (2015): 3.791



Figure 1: Block Diagram of Adaptive Edge Enhanced Algorithm

A. Bilinear Interpolation

Bilinear interpolation [1], [2], [4] is a resampling method; it uses the four nearest neighboring pixel value, and then new pixel values are calculated by weighted average of the four nearest-neighbor pixels based on its distance.

Linear interpolations are performed in one direction (horizontally) and then one more linear interpolation is performed in the perpendicular direction (vertically).



Figure 2: Bilinear Interpolation

The interim pixels are P(i', j)P(i', j+1) are created by linear interpolation in X direction and can be calculated as,

$$P(i', j) = (1-fx) \times P(i, j) + fx \times P(i+1, j)$$
 (1)

$$P(i', j+1) = (1-fx) \times P(i, j+1) + fx \times P(i+1, j)$$
(2)

Where fx is the scale parameter in horizontal direction (X direction). After interpolating in X direction, the values of interim pixels P(i', j), P(i', j+1) are generated. The resulting output pixels (P', j') can be obtained by linear in Y direction and can be calculated as,

$$\begin{split} P(i', j') &= [(1-fx) \times P(i, j) + fx \times P(i+1, j)] \times (1-fy) + [(1-fx) \times P(i, j+1) + fx \times P(i+1, j+1)] \times fy \end{split}$$

Where fy is the scale parameter in vertical direction (y direction). The fx and fy are zooming ratios of the x and y direction. Bilinear interpolation is more popular in VLSI implementation because of its low complexity. After bilinear interpolation is completed, edges become blurry and give aliasing effect.

B. Edge-Detecting Technique

The edge detecting technique uses a sigmoidal edge detecting method [8]. The interpolated pixel P(k)can be calculated as four closest pixels are P(i-1), P(i), P(i+1), P(i+2) placed at i-1, i, i+1, i+2 respectively as shown in Figure 3



Figure 3: Local characteristics neighboring around the target interpolated pixel P(k)

In this work, a linear space-variant sigmoidal edge detecting model [22]-[23] is selected as the proposed edge detecting algorithm due to its low complexity and memory requirement.

The local characteristics neighboring around the target interpolated pixel P(k) can be evaluated by the four nearest neighboring pixels P(m-1), P(m), P(m+1), P(m+2), as shown in Figure 3. The coordinates of the interpolated pixel P(k) and four neighboring around pixels are located at k, m-1, m, m+1, and m+2, respectively. By using sigmoidal edge detecting model, the asymmetry of the local characteristics neighboring around P(k) can be evaluated by

$$A = |P(m+1) - P(m-1)| - |P(m+2) - P(m)|$$
(4)

where A is asymmetry parameter defined to evaluate the asymmetry of the data in the neighborhood of P(k).

By using sigmoidal functions, the asymmetry of the edges can be summarized as

A=0, edges are symmetry on the left side and right side.
A>0, edges are more homogeneous on the right side
A<0, edges are more homogeneous on the left side

The edge detecting method used to obtain the local characteristics of edges. The interpolated images become smooth and there is a loss of edge information. To protect edge information using an adaptive edge enhancement technique. For example, the edge detector is used to search edges on the left side, if more homogeneous of the left side (E<0). To exclude the loss of edge information after bilinear interpolation, right side of two pixels is adaptively enhanced by the Sobel filter.

C. Sobel Filter

Sobel filter is applied to perform edge detection. Sobel filter is used to reduce blurring and aliasing artifacts. It uses two kernels with 3×3 sizes, one estimating the gradient in the x-direction (horizontal) and the other gradient in the ydirection(vertical). These kernels are each convolved with the image.



The algorithm calculates the gradient of the image intensity at each point, and then gives the direction to increase the image intensity at each point from light to dark. Edge areas define strong intensity contrasts which darker or brighter.

To measure gradient magnitude is given by

$$|\mathbf{H}| = \sqrt{\mathbf{H}\mathbf{x}^2 + \mathbf{H}\mathbf{y}^2} \tag{5}$$

3. Experimental Results

To evaluate the performance of the proposed adaptive edge enhanced scaling algorithm, one test image (256×256) is used in the simulation. First perform upscaling an image, and then down-scaling an image, finally get the same size of the original image. The Peak-Signal to Noise Ratio (PSNR) is commonly used to measure the quality of a noisy approximation of the m \times n refined image and the original image.

The Mean Squared Error defines the cumulative squared error between the refined image and the original image. The low value of the MSE is considered as low error. The MSE defined as

$$MSE = \sum_{i=1}^{x} \sum_{j=1}^{y} \frac{(Aij - Bij)^{2}}{x \times y}$$

Where x and y represents the number of rows and columns of the pixels of the original image.

The PSNR is defined as

 $PSNR = 10 \log_{10} \frac{R^{2}}{MSE}$

The pixels are represented by eight bits per sample, so the maximum value of each pixel(R) is 255. The quality of the scaled image expressed in decibel (dB).

Table 1: Comparison of PSNR for Image ZoomingAlgorithms from the Size of 256×256 To 512×512

	Sharpening spatial	
	filter, edge	Sobel filter, edge
Image Taken	detector,	detector, bilinear
	bilinear	interpolation
	interpolation	
Cameraman image	36.08	42.11

By using two methods one Cameraman image is scaled up to double the size and then refined to original size. First method uses a sharpening spatial filter, edge detector, and bilinear interpolation.

Second method uses a sobel filter, edge detector, and bilinear interpolation. Table I list the PSNR results of Peppers test image. The experimental results show that the proposed adaptive edge enhanced technique achieves better image quality.

The input image and corresponding output from the algorithm that has been developed



We have also performed this calculation using Xilinx software and obtained waveforms for this results they are follows.



By using two methods one Cameraman test image is scaled up to double the size and then refined to original size. First method uses a sharpening spatial filter, edge detector, and bilinear interpolation.

Second method uses a sobel filter, edge detector, and bilinear interpolation. Table I list the PSNR results of Cameraman test image. The experimental results show that the proposed adaptive edge enhanced technique achieves better image quality.

4. Conclusion

This paper proposed an adaptive edge enhancement technique for image zooming application, which is easy to

implement in VLSI. The sobel filter solved the blurring and aliasing artifacts caused by bilinear interpolation. The adaptive edge enhanced technique is effectively enhanced the edge features of scaled images. An algebraic manipulation and hardware sharing technique in this design greatly reduces the computing resources costs. Comparing results of the proposed method will improve the image quality.

5. Future Scope

Future research in the Image scaling technique is widely used in the field of digital image processing. In common applications, such as medical image processing, image zooming, computer graphic, online videos and etc, image scaling plays a more and more important role. Nowadays, the image scalar is widely adopted in electric devices such as portable healthcare device, electronic measurement equipment, digital apparatus, digital camera, digital photo frame, mobile phone, touch panel computers, and etc. It has become a significant trend to design a low-cost, high quality, and high performance image scalar by VLSI technique.

Also we can take result of Image Scaled by other methods and algorithms which can be then compared with Image Scaling by VLSI Technique. Which will help you compare the Image scaling of both methods and Techniques.

References

- [1] Shin–Lun Chen "VLSI Implementation of an Adaptive Edge-Enhanced Image Scalar for Real Time Multimedia application" IEEE Trans. circuits and systems for video technology, 2013.
- [2] Shin–Lun Chen "VLSI implementation of a low-Cost High-quality Image Scaling Processor", IEEE Trans. circuits and system, vol.60, no.1, Jan.2013
- [3] C. C. Huang, P. Y. Chen, and C. H. Ma, "A novel interpolation chip for real-time multimedia application," IEEE Transaction on Circuits and Systems for Video Technology, Vol. 22, no.10, pp.1512-1525, Oct.2012.
- [4] S. L. Chen, H. Y. Huang, and C. H. Luo, "A low-cost high-quality adaptive scalar for real-time multimedia applications," IEEE Transaction on Circuits and Systems for Video Technology, Vol. 21, no. 11, pp. 1600-1611, Nov. 2011.
- [5] H. Kim, Y. Cha and S. Kim, "Curvature interpolation method for image zooming," IEEE Trans. Image Process., vol. 20, no. 7, pp.1895–1903, Jul.2011.
- [6] C. C. Lin, M. H. Sheu, C. Liaw, and H. K. Chiang, "Fast first-order polynomials convolution interpolation for real-time digital image reconstruction," IEEE Transaction on Circuits and Systems for Video Technology, Vol. 20, no. 9, pp. 1260-1264, Sep. 2010.
- [7] J. W. Han, J. H. Kim, S. H. Cheon, J. O. Kim and S. J. Ko, "A novel image interpolation method using the bilateral filter," IEEE Trans. Consumer Electronics, vol. 56, no. 1, pp. 175-181, Feb. 2010.
- [8] P. Y. Chen, C. Y. Lien and C. P. Lu, "VLSI Implementation of an Edge-Oriented Image Scaling

Processor, "IEEE Trans. VeryLarge Scale Integration Systems, vol. 17, no. 9, pp. 1275-1284, Sept.2009.

- [9] Luming Liang, "Image Interpolation by Blending Kernels," IEEE Signal Processing Letters, vol. 15, no. 1, pp. 805–808, Dec. 2008
- [10] A. Amanatiadis, I. Andreadis, and K. Konstantinidis, "Design and implementation of a fuzzy area-based image-scaling technique," IEEE Transaction on Instrumentation and measurement, Vol. 57, no. 8, pp. 1504-1513, Aug. 2008.
- [11]X.Zhang and X.Wu, "Image interpolation by adaptive 2-D autoregressive modeling and soft-decision estimation", IEEE trans. Image process, vol.17, no.6, pp.887-896, Jun.2008.
- [12] C. T. Lin, K. W. Fan, H. C. Pu, S. M. Lu and S. F. Liang, "An HVS-directed neural-network-based image resolution enhancement scheme for image resizing," IEEE Trans. Fuzzy Systems, vol. 15, no.4, pp.605-615, Aug.2007.
- [13] Q. Wang and R. K. Ward, "A New Orientation-Adaptive Interpolation Method," IEEE Trans. Image Process., vol. 16, no. 4, pp.889–900, Apr.2007.
- [14] C. H. Kim, S. M. Seong, J. A. Lee and L. S. Kim, "Winscale : an image-scaling algorithm using an area pixel model", IEEE trans. Circuit and System for Video Technology, vol. 13, no. 6, pp. 549-55, Jun.2003.

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